THE LIME TREE AND ITS PRODUCTS.[1]

ONE of the most promising of the newer industries of the West Indies is the cultivation of limes. Lime products, at the present time, form the principal exports from the island of Dominica, and are second only to cotton in the island of Montserrat. Large tracts of land have recently been taken up in British Guiana for the cultivation of lime trees, and progress is being made at St. Lucia, Carriacou, and elsewhere.

Lime fruits in a fresh condition are now largely exported from Dominica to New York, London, and Manchester. They can be used for every purpose to which the lemon is put, and are considered more economical. Raw lime-juice is exported for making cordials, and the concentrated juice forms one of the principal sources of commercial citric acid. The essential oil, both hand-pressed and distilled, is of value in perfumery.

The tree appears to be confined to tropical and subtropical zones, and has not nearly so extensive a range of growth as the orange or lemon. In these circumstances the West Indian Department of Agriculture is well advised to issue clear and popular instructions for planting and cultivating the tree, and for dealing with the various products. The Department has, indeed, gone further, and has distributed many thousands of lime plants; in consequence, the value of the exports last year from Dominica was more than 77,000*l*. Of the two varieties, the ordinary spiny and the spineless, the juice from the latter appears to be the purer and richer in acid.

"The A.B.C. of Lime Cultivation" is drawn up by Mr. Joseph Jones, curator of the Botanic Station at Dominica, and Mr. J. C. Macintyre, a large grower. It gives a concise but eminently readable account of the crop, and merits more than a local circulation.

Dr. Watts deals in the West Indian Bulletin with the question of citric acid. It appears that manufacturing chemists prefer buying calcium citrate rather than the concentrated lime-juice, and Dr. Watts describes methods of preparing the salt. Chalk is added in proper quantity to the juice, and the precipitated citric acid is allowed to settle, is then washed with hot water and dried. At present drying constitutes a great difficulty; the experiments show that a centrifugal machine works well, but the best type still remains to be determined, and many other details of the manufacture have also to be worked out.

The whole industry appears to be a very promising addition to the resources of the West Indies, and the Department of Agriculture is to be congratulated on the vigorous action it is taking.

MATHEMATICS AND PHYSICS AT THE BRITISH ASSOCIATION.

THE president of Section A (Mathematical and Physical Science) delivered his address on Thursday, September 3. This address has already appeared in full in NATURE of September 3 (p. 425). It was followed by an important discussion on the isothermal layer of the atmosphere. Of this, also, a detailed account has already been given in NATURE (October 1, p. 550).

Prof. W. F. Barrett (who was one of the vice-presidents of the section) concluded the morning's proceedings with an account of an ingenious combined optometer and entoptiscope. On meeting again after lunch various reports of committees were taken. The committee on improving the construction of practical standards for electrical measurements directed special attention to the conclusion of the electrical measurements of certain of the fundamental units which have been in progress for some time at the National Physical Laboratory. The E.M.F. of the Weston cadmium cell as set up in the laboratory is given as $1{\cdot}0183_0$ at 17° C. Six forms of silver voltameter give (with proper precautions) the value 1·11827 milligrams for the silver deposited by 1 ampere per second. There are two important appendices to the report:—(1) on the secular changes of the standards of resistance at the National Physical Laboratory, by F. E. Smith; and (2) specifications for the practical realisation of the definitions of the international ohm and international ampere, and instructions for the preparation of the Weston cadmium cell. The other reports read were those rendered by the committees on kites, geodetic arc in South Africa, meteorological observations on Ben Nevis, and magnetic observations at Falmouth Observatory.

The large number of papers down for reading in this section made necessary a separation on three of the days into three departments, which sat concurrently. This trifurcation began on Friday, September 4. The mathematical department began with the reading of the report of the committee on the further tabulation of Bessel functions. Dr. T. W. Nicholson then communicated some formulæ useful for the computation of Bessel functions when the order and the argument are both large. Dr. E. W. Hobson followed with a paper on Sir W. Hamilton's fluctuating functions. In this paper Dr. Hobson reviewed and criticised Hamilton's work, and he specially directed attention to the extraordinarily sure instinct with which Hamilton anticipated many of the results of the modern theory of the definite integral, and steered clear of the many pitfalls which surround this particular subject, in spite of the imperfect and often erroneous ideas on this matter which were current at the time among mathematicians. Prof. Lamb, in the discussion which followed, referred to this point, and remarked that the inaccuracy of the methods of the older analysts was often more apparent than real, because they took for granted much of which they were aware, but which it is now the fashion to write down explicitly.

Dr. S. H. Burbury then read a paper on the law of equipartition of energy, in which he showed that this law was really independent of the Boltzmann-Maxwell assumption that the variables were uncorrelated. Prof. J. C. Fields gave an account of a new proof of a theorem recently discovered by himself, to which he has given the name of the complementary theorem. The full statement of the theorem, which deals with properties of algebraic functions of a complex variable, is somewhat long, but the theorem is of a most general character, and includes a large number of important results previously known. Mr. Robert Russell explained a new method of introducing the elliptic functions. Denoting the expression

$$a_0x^4+4a_1x^3+6a_2x^2+4a_3x+a_4$$

by $f(x)$, and by δ one root of $f(x)=0$, he considered the functions

$$u=\int_\delta^x\frac{dx}{\sqrt{f(x)}}\quad v=\int_\delta^y\frac{dy}{\sqrt{f(y)}}$$

He then showed by simple reasoning that the expression

$$\frac{x-y}{(x-\delta)(y-\delta)}$$

was invariant for transformations of the type

$$x=(l\xi+m)/(l'\xi+m')$$

and thence that a function ϕ existed such that

$$\frac{x-y}{(x-\delta)(y-\delta)}=\phi\frac{(u-v)\,\phi\,(u+v)}{[\phi(u)]^2[\phi(v)]^2}$$

This function ϕ, then, turns out to be no other than the ordinary σ-function, which, in this method, is therefore fundamental.

Mr. Russell also gave a new proof of Legendre's identity

$$EK'+E'K-KK'=\frac{\pi}{2}$$

Commenting upon the paper, the chairman (Prof. A. E. H. Love) mentioned that he had recently devised a physical proof of Legendre's identity by considering the magnetic potential of a circular current.

[1] "The A.B.C. of Lime Cultivation" (Imperial Dept. of Agriculture for the West Indies, 1908.)
Bulletin of the Department of Agriculture, Jamaica, 1908. Vol. vi. Parts ii. and iii.
West Indian Bulletin. Vol. viii., pp. 167–172.

The proceedings of the general physics department began with a paper from Sir W. Ramsay with the title "Do the Radio-active Gases (Emanations) belong to the Argon Series?" The experimental part consisted in the examination of the residues of the fractionation of 120 tons of liquid air with the object of discovering new elements. The final residue of 0·3 c.c. had a spectrum differing in no respect from xenon, and it is concluded that if there is a heavier constituent in air than xenon its amount does not exceed 1/25 billionth of the whole. A consideration of the periodic table reveals gaps at 178, 216, and 260, and it is rendered probable that they are respectively unstable emanations, viz. those of thorium, radium, and actinium. Discussing this paper, Prof. Rutherford outlined his well-known argument from the mode of disintegration of uranium and its successors that radium emanation has an atomic weight of 222, but did not attribute importance to the difference between this and 216. It is not possible to apply the same argument to the other radio-active elements, because more than one alpha particle may be thrown off at a time. Actinium, he thought, might belong to a side branch. It seemed improbable that there should be an emanation higher than uranium, and therefore he discountenanced the view that the value 260 belonged to actinium emanation. Mr. S. Russ observed that he recently made a direct comparison between the coefficients of diffusion of the emanations from thorium and actinium, with the result that the molecular weight of that of actinium is *less* than that of thorium. Sir W. Ramsay, in replying, urged that Prof. Rutherford had left out of account the production of neon, which must be explained by the occurrence of a group of alpha particles. Prof. Rutherford rejoined that he was not convinced of the production of neon in radio-active changes.

Mr. W. Makower followed with a paper on the number and absorption of the β particles emitted by radium. The law of absorption by glass found for the β rays from radium B and C is the same as that for aluminium found by H. W. Schmidt, the radiation being measured in both cases by the ionisation produced by the rays after traversing different thicknesses of glass. It was found to be the same when measured by the *charge* received by an insulated brass cylinder (which surrounded the glass tube containing the emanation), different thicknesses of glass being interposed. It is concluded that when rays pass through matter the absorption is not due to scattering, but to an actual stoppage of the particles. The number of β particles emitted per second by the radium C in equilibrium with 1 gram of radium is found experimentally to be $4{\cdot}9\times10^{10}$. Prof. Rutherford explained that the value he expected from theoretical considerations for the number from both B and C was $6{\cdot}8\times10^{10}$ instead of $9{\cdot}8\times10^{10}$ as deduced from Mr. Makower's experiments. To remove the discrepancy we might assume not merely one α for one β particle. Prof. McClelland welcomed the view that scattering is not an important factor, though his recent experiments show that some scattering is present, together with a *sending out* of secondary particles. Prof. J. J. Thomson had not the slightest doubt, from his own experiments, that there is a large amount of scattering, and that absorption is due to this divergence. The ultimate fate of a particle may be that it sticks in, but it is repeatedly deflected first. Prof. H. A. Wilson expressed an interest in the subject, partly on account of its bearing upon his suggestion of the *smallness* of the α particle. Sir O. Lodge tried to reconcile the opposing statements by asking whether it is not necessary to distinguish between absorption by conductors (as in Prof. J. J. Thomson's experiments) and by non-conductors (as in Mr. Makower's).

An account was next given by Sir J. Dewar of his recent work on the rate of production of helium from radium (*v.* Proc. Roy. Soc., A, vol. lxxxi., No. 547, p. 280). After extreme precautions, the rate of production is found to be about 0·37 cubic mm. per gram per day, a number which is of the same order of magnitude as Rutherford's theory requires. Turning to the question of the helium in the atmosphere, he considered that two or three million years would be required to produce it from rocks. Prof. R. J. Strutt remarked that 100 billion tons of rock would be required if the supply of helium were kept up in this way. Probably the supply is supplemented by a store in the interior of the earth. A difficulty in making a trustworthy estimate of geological time arises from the fact that helium escapes. Sir O. Lodge pointed out that the rock required would only occupy 20 kilometres cube—a very moderate amount.

In the department of cosmical physics, Prof. J. Milne, in introducing the report on seismological investigations, remarked on the necessity for accurate time signals in seismological work and the difficulty of arranging terms with the Post Office for the transmission of such signals to the central observatory at Shide. After a short explanation of the instrumental records obtained and a statement of the shocks noted in 1907, he proceeded to point out that earthquakes travelled more freely towards the west, or against the motion of the earth, than towards the east, while very few earthquakes travelled across the equator. A very important section of this year's report is a catalogue of nearly 900 earthquakes recorded in China between 1800 B.C. and 1834 A.D.

The remaining papers were astronomical in character. Sir Robert Ball described a generalised instrument presenting the features common to the altazimuth, meridian circle, prime vertical instrument, equatorial, and almucantar, and a single set of equations represented the coordinates of the star relatively to three rectangular axes which could be defined in the generalised instrument.

Sir Howard Grubb described a new form of divided object-glass telescope in which the two half object-glasses are reversed and placed back to back; this arrangement permits the use of the necessary diaphragms, and a circular wedge is conveniently employed over one half for producing a relative shift of the rays through the two halves. Sir Howard Grubb also read a paper on the reflecting telescope and its suitability for physical research—an historical account of the subject. In the discussion Prof. H. H. Turner emphasised the importance of Common's work in connection with the reflecting telescope, and Sir D. Gill advocated the use of the Cassegrain form modified by Hale. Father Cortie described a reflector he had used at Stonyhurst for solar work, and mentioned the advantage of speculum metal over silvered glass for violet and ultra-violet light.

Sir Howard Grubb gave a description of the new spectroheliograph for the Madrid Observatory, which, instead of sliding in a straight line as usual, describes the arc of a circle of which the object-glass for focussing the sun's image is the centre.

A paper was next read by Prof. H. H. Turner on the relation between intensity of light, time of exposure, and photographic action. Representing these by the letters I, t, and E respectively, a new law, $E \propto It^{0{\cdot}8}$, is given as closely representing the facts concerning stellar photographic effect instead of the law $E \propto It$. This means that with an increase of exposure equivalent on the old scale to five magnitudes only four were obtained. Sir W. Abney stated that since the sensitiveness of a plate is different for different wave-lengths, the full equation must contain a term involving λ. Mr. R. T. A. Innes suggested the possibility of an influence arising from the diameter of the stellar image. Sir D. Gill felt that the law should be accepted with reservation, since different observers obtained different results, but Prof. Turner, in replying, contended that all observers got the same results if they only knew it.

Prof. F. W. Dyson contributed a paper on the systematic motion of the stars, which gives the results obtained so far from an unfinished investigation. It appears that the stars of large proper motion ($>20''$ per century) have apparent drifts to two points in the sky, but a difficulty is presented in the explanation of this as due to two streams. Mr. A. S. Eddington thought that the inequality in the numbers of stars in the two streams could be explained by the omission of stars of small proper motion, but admitted that his own results might ultimately require modification.

The proceedings on Monday, September 7, began in general session with a discussion on the theory of wave motion. This was opened by Prof. Horace Lamb, who explained that his object was to establish a better understanding between students of mechanics and meteor-

ologists and other men of science who were confronted by phenomena in which the characteristics of wave motion appeared prominent. First there were the large-scale oscillations of the atmosphere, shown in the oscillation of barometric pressure. These waves were not mainly gravitational. The principal periods of their free oscillation are 22, 16, . . hours. If we take into account the rotation of the earth, the character of the oscillation and the periods are modified. Laplace's theory of the tides, which has been very much improved by Hough, applies to an ocean covering the globe, and the only difficulty that arises when we wish to apply this to the atmosphere comes from differences of temperature. If we neglect these differences and apply Hough's theory to the atmosphere, the second type of oscillation has a period of about twelve hours. If we examine the facts as recorded by the barometer, we find the well-known diurnal oscillation irregular in amplitude and phase, and depending in a marked way on the height above sea-level, and, secondly, the semi-diurnal oscillation, extremely regular in amplitude for places in the same latitude and in phase for places in the same longitude.

The first thing that suggests itself is that this is a tide caused by the sun's attraction; but the corresponding lunar tide ought to be more marked, whereas, actually, the lunar tide is almost absent. Moreover, the phase is wrong in sign, and it is too big. Lord Kelvin was the first to suggest that the semi-diurnal tide was a temperature effect. The daily variation of temperature is not harmonic, and when it is analysed there is a definite component with a half-day period. The objection to attributing the semi-diurnal pressure variation to this is that the latter is extremely regular, while the temperature variation changes considerably with the locality. Margules has shown that on a rotating earth the period of free oscillation of the atmosphere lies very near to twelve hours, and consequently a forced oscillation of this period would be magnified.

Passing on to local oscillations, Prof. Lamb said these were probably mainly gravitational. The atmosphere might be treated as an incompressible fluid because of the relatively large value of the velocity of sound.

If we have two fluids of densities ρ and ρ', with a horizontal surface of separation, the velocity of waves at this surface is $\sqrt{\frac{g\lambda}{2\pi}\frac{\rho-\rho'}{\rho+\rho'}}$. Waves of this type occurring in the atmosphere would not appreciably affect the barometer at a place some distance below the surface of separation owing to the fact that the intensity of the disturbance diminishes exponentially. Only in the case of very long waves should we expect the oscillation to be shown on the barometric curve.

If the upper fluid is the denser, the amplitude of the disturbance increases rapidly, and we may get a series of filaments as the result of disturbance. So long ago as 1857 Stanley Jevons conceived the possibility of cirrus clouds arising in this way, and made experiments with liquids in verification.

If the change of density is not abrupt, but takes place across a transition layer, the character of the motion may change. It is probable that the structure of the disturbance will be larger. If we have difference of velocity as well as of density, the wave-velocity at the surface of separation is given by

$$V=\frac{\rho v+\rho' v'}{\rho+\rho'}\pm\sqrt{\frac{g\lambda}{2\pi}\frac{\rho-\rho'}{\rho+\rho'}-\frac{\rho\rho'}{(\rho+\rho')^2}(v-v')^2}.$$

If λ is small, the expression under the root becomes negative, indicating that the condition of affairs is unstable. This instability is more effective than viscosity in reducing an abrupt change of velocity to a gradual change taking place across a transition layer. The question then arises as to whether we get rid of the instability when the change becomes a gradual one. Helmholtz investigated the problem of waves at a surface of separation in the atmosphere. He concluded that, instead of instability, we might have waves of permanent type of finite amplitude. The question of the stability of these waves is still an open one.

In the application to the atmosphere it is deduced that at the crests of the waves there may be sufficient condensation through the expansion and cooling of the air to make the crests visible. Before this can be settled we need a picture of what really does happen when we cross a layer where these wave-like clouds are formed. Mathematicians have gone nearly as far as they are able without precise information on such points.

Dr. Shaw then showed some lantern-slides illustrating wave motion in the atmosphere recorded by the microbarograph. In some cases a large sudden increase or decrease in the pressure was followed by a series of waves falling off rapidly in intensity. In other cases similar sudden changes were unaccompanied by waves, while in others still waves were formed without any sudden change occurring. He suggested the possibility of a current of air in rapid motion acquiring a dynamical stability as the result of the motion in such a way that a disturbance of the current might produce an oscillation of the current as a whole in a horizontal direction.

Mr. Wedderburn gave the results of observations of temperature in Loch Ness, showing how temperature oscillations arose from the circulation of the water. He showed the results of experiments on the circulation of water in a vessel of parabolic cross-section over which a strong current of air was passing. The liquid circulated in two distinct systems with a definite surface of separation.

Sir William White spoke on ocean waves and on the importance of the new experimental tank to be set up at the National Physical Laboratory.

Prof. Lamb's paper has been ordered to be printed in full in the report.

At the conclusion of this discussion the section again trifurcated.

In the department of mathematics, Sir Robert Ball opened the meeting with an account of the physical applications of the theory of screws, and referred specially to the excellent work done by the late Prof. C. J. Joly on quaternions, in which the present paper had its origin. Sir Robert showed that the theory of linear vector functions was really identical with that of the composition of screws, and that the whole subject became thereby much simplified, and the formulæ far more concisely expressed.

Dr. T. W. Nicholson read a paper on the inductance of two parallel wires. The author stated that the ordinary formula is inaccurate when the currents are of high frequency; in the present paper new formulæ are given which give a correct result for frequencies as high as 10^8.

Prof. F. Purser contributed a paper on the æther stress of gravitation. Maxwell had selected as a particular solution of the fundamental equations a pressure $R^2/8\pi$ along the lines of gravitating force, and an equal tension perpendicular to these lines, R being the resultant force of gravitation on unit mass, but there are difficulties in accounting for these by corresponding strains. Prof. Purser shows that the difficulties are removed if we consider that we are not bound to Maxwell's special solution, but may take such a solution as may be deduced from a state of strain according to the laws for (say) a homogeneous isotropic æther.

Several papers were taken as read in the absence of the authors.

The proceedings in the department of general physics commenced with a paper by Sir W. de W. Abney, K.C.B., on a new three-colour camera, in which the stereoscopic effect arising when three images are taken simultaneously by three lenses lying side by side is reduced to a minimum. Incidentally, it was pointed out that in this camera the mirrors are made of steel varnished with celluloid dissolved in acetone. Dr. Harker directed attention to Cowper-Coles's use of metallic cobalt, and Prof. W. F. Barrett, who was in the chair, strongly recommended galena for the purpose.

Sir Oliver Lodge described a new method for measuring large inductances containing iron which has been devised by him in collaboration with Mr. Benjamin Davies. A special galvanometer, consisting of a well-damped coil moving *dead beat* in a strong magnetic field, is connected in series with the inductance and a specially designed alternator giving a simple harmonic current. A switch enables the inductance to be suddenly replaced by a non-

inductive resistance R′, which is adjusted until the amplitude of oscillation is the same in both cases. Then the self-inductance is R′ divided by the frequency-constant of the alternator. The strength of the current involved in this measurement is known by imitating the deflection with a known steady current.

Prof. A. M. Worthington then showed a remarkable series of instantaneous photographs exhibiting a new feature in the splash of a rough sphere. This new feature appears when the height of fall is increased beyond a certain critical value. Below the critical height the splash is characterised by an upward jet thrown high into the air. It is now found that when the critical height is passed the long cylindrical column of air which follows the sphere in its descent through the liquid is pierced by a central *downward* jet directed from above along the axis of the air column. This is due to the permanent closing, at an early stage, of the mouth of the air column by a film of the liquid, and to the subsequent reduction of the pressure of the confined air through the piston-like action of the sphere when its momentum is large enough. The morning's proceedings concluded with a paper by Prof. F. T. Trouton on the analogy between adsorption from solutions and aqueous condensation on surfaces. When cellulose is inserted into the solution of a dye adsorption takes place, the amount of which depends upon the concentration and the temperature, but the amount can be kept at any particular value by simultaneously varying both. When such corresponding values of concentration and temperature are plotted against one another the curves are similar to one another, and, further, they are similar to the ordinary saturation curve for the solute in question. This result is analogous to the law of the temperature isoneres for water vapour when we substitute osmotic pressure for concentration and the saturation curve of the solution for the boiling-point curve, viz. that at different temperatures the pressure ordinate of a given isonere is a constant fraction of the corresponding ordinate of the boiling-point curve. Thermodynamical considerations were given in favour of both results.

On resuming the sitting in the afternoon a paper by Dr. J. A. Harker and Mr. F. P. Sexton was read (by the former), on the effect of pressure on the boiling point of sulphur. The results are closely represented by the formula

$$T = T_s + 0{\cdot}0904\,(p - 760) - 0{\cdot}0000519\,(p - 760)^2,$$

where T is the temperature of the vapour on the air-scale at the pressure p in mm., and T_s is the normal boiling point. This gives a result much greater than the value 0·082 mm. per degree which is usually employed, and which is based on Regnault's observations.

Dr. Glazebrook then communicated a paper on the photometric standard of the National Physical Laboratory. Wet- and dry-bulb thermometers are found to give results 20 per cent. higher for the humidity of the air than hygrometers of the Assman pattern, which are used at the Reichsanstalt. The former were used at the National Physical Laboratory in connection with the effect of humidity on the pentane lamp. It is proposed to change the standard humidity from 10 to 8 litres per cubic metre, and thereby maintain the light value unchanged.

A paper by Mr. John Brown, on a dry Daniell pile, was taken as read in the absence of the author.

Meanwhile, the department of cosmical physics had been meeting, the first paper being by Sir John Moore, on the question, Is our climate changing? The object of the paper was to test the accuracy of the popular opinion that there is a progressive postponement of season, an opinion strengthened by occasional abnormal weather conditions, such as the snow and frost at the end of April, 1908, and the summer heat at the beginning of September, 1906. From an examination of old records and of the long series of observations made at Greenwich, the conclusion was drawn that no appreciable change has taken place in our climate during the past six centuries.

Dr. Shaw pointed out as instances of progressive changes bearing on this question the gradual receding of glaciers and of the Antarctic ice barrier, which had lost thirty miles in ten years.

Commander Campbell Hepworth, C.B., of the Meteorological Office, read a paper on the changes in the temperature of the North Atlantic and the strength of the trade winds. The N.E. trade wind is strongest in April (13·5 miles per hour) and weakest in September (7·4 miles per hour). The S.E. trade wind is strongest in February (15·5 miles per hour) and weakest in May (13·7 miles per hour).

The surface temperature was lowest in March and highest in August.

There appears to be a relation between the departures from mean velocity in the trade winds in one year and the departures from mean temperature in the surface waters in the succeeding year.

A paper by Mr. F. J. M. Stratton, on the constants of the lunar libration, described how a re-investigation of the heliometer observations of Mösting A made by Schlüter at Königsberg in the years 1841–3 has been undertaken in the hope of reconciling the conflicting sets of constants given by Drs. Franz and Hayn.

Mr. W. Makower, Miss Margaret White, and Mr. E. Marsden contributed the results of observations on the electrical state of the upper atmosphere. The current down a kite wire when the kite is at an altitude of 1500 metres is of the order of 2×10^{-4} amperes. It increases with the height more quickly than according to the linear law, and varies in a more or less regular way with the wind velocity.

On Tuesday, September 8, the section was also divided into three parts. In the mathematical department two papers were contributed by Prof. A. W. Conway. In the first—application of quaternions to problems of physical optics—Prof. Conway showed how the analytical treatment of such problems becomes both simpler and more elegant when they are expressed in quaternion notation. As examples he worked out the problem of reflection and refraction at a plane surface, showing how to obtain the ratio of the intensities; and also that of the propagation of light through a rotationally active medium such as a sugar solution.

Prof. Conway's second paper dealt with the distribution of electricity in a moving sphere. The sphere was assumed of invariable form, and its velocity less than the velocity of light. In the discussion which followed, Prof. Conway mentioned that Mr. Varley had recently found that a point of inflection in the curve of mass to velocity was indicated by experiment, and no theory could be entirely satisfactory which did not show such an effect.

Major P. A. MacMahon read a paper on a problem known as that of the "Scrutin de Ballotage." This problem relates to the probability that when two candidates are up for election, the candidate finally successful shall be throughout at the top of the poll. Major MacMahon has generalised this by considering an election where there are any number of candidates, and has found the probability that at any time during the election the candidates shall be in the same order as they are finally.

Prof. R. W. Genese followed with a paper on the analysis of projection. He showed that if the vanishing lines of two figures in space perspective be taken as axes of y, Y respectively, and the lines where the planes of the two figures are met by a plane through the vertex of projection perpendicular to both as axes of x, X respectively, then the coordinates are connected by the relations

$$\frac{y}{Y} = \frac{x}{Z} = \frac{z}{X},$$

z, Z being constants, which may be taken as unity, and the curve $y = f(x)$ in one plane transforms into the curve $y = xf(1/x)$ in the other.

Mr. H. Bateman then explained a method of obtaining solutions of problems in geometrical optics by conformal transformations in space of four dimensions. He showed that for such transformations (of which inversion is an important particular case) the equations

$$\left(\frac{\partial V}{\partial x}\right)^2 + \left(\frac{\partial V}{\partial y}\right)^2 + \left(\frac{\partial V}{\partial z}\right)^2 + \left(\frac{\partial V}{\partial w}\right)^2 = 0,$$

and

$$\frac{\partial^2 V}{\partial x^2} + \frac{\partial^2 V}{\partial y^2} + \frac{\partial^2 V}{\partial z^2} + \frac{\partial^2 V}{\partial w^2} = 0,$$

are invariant, and consequently from any one solution of such equations a new solution can be at once deduced.

Mr. Bateman also pointed out that the twenty-four known transformations of the hypergeometric equation into itself arise naturally from the consideration of rotations in four-dimensional space.

Prof. Purser read a paper on motion of solids in an incompressible fluid, and discussed the validity of the application of Lagrange's equations of motion to such a case.

Prof. E. T. Whittaker, in a communication entitled "The Extension of Optical Ideas to the General Electromagnetic Field," showed that the disturbances of the æther could be expressed in terms of two functions, F, G, as follows:—

$$\text{Electric vector} = \left(-\frac{\partial^2 F}{\partial y \partial t}+\frac{\partial^2 G}{\partial x \partial z},\ \frac{\partial^2 F}{\partial x \partial t}+\frac{\partial^2 G}{\partial y \partial z},\ \frac{\partial^2 G}{\partial z^2}-\frac{1}{c^2}\frac{\partial^2 G}{\partial t^2}\right).$$

$$\text{Magnetic vector} = \left(\frac{\partial^2 G}{\partial y \partial t}+\frac{\partial^2 F}{\partial x \partial z},\ -\frac{\partial^2 G}{\partial x \partial t}+\frac{\partial^2 F}{\partial y \partial z},\ \frac{\partial^2 F}{\partial z^2}-\frac{1}{c^2}\frac{\partial^2 F}{\partial t^2}\right),$$

c being the velocity of light, and F, G solutions of Laplace's equation of degree zero. Prof. Whittaker suggested that these functions, F, G, might be taken as two scalars defining the state of the æther in the same way that temperature and pressure define the state of a gas.

The general physics department on this day began with a suggestion with regard to the meaning of valency, by Mr. H. Bateman. In this paper the valency of an atom is identified with the number of degrees of freedom of certain displacements. A molecule has lost all these degrees. A single atom or a cluster which still possesses "valency" degrees of freedom may be regarded as an ion. A scheme representing geometrically a sequence of processes which possess some of the features exhibited by those taking place within the atom was based on the theory of inversion. A transformation of a specified type by inversion with respect to two spheres was shown to depend on eight parameters, a fact which may be of significance in regard to eight being the maximum valency of an atom. Prof. Rutherford congratulated the author, but pointed out that it had not yet been shown that such a transformation by inversion could take place physically. In response to a question by the chairman (Prof. C. H. Lees), Mr. Bateman stated that, for an atom such as he pictured, if the state of motion is not steady the spectral lines would not be sharp; otherwise they would be sharp. After any disturbance the spectrum at first produced would be a continuous spectrum.

Prof. J. A. McClelland followed with an important summary of our present knowledge of secondary radiation. It is unfortunate that it is not possible to further summarise it in the few words available in these columns. In the discussion, Prof. J. C. McClennan insisted that it is necessary to determine the velocities and to employ the magnetic field more before the various effects will be disentangled.

Then Prof. E. Rutherford gave the conclusions from his recent experiments on the scintillations of zinc sulphide (as in the spinthariscope). The effect he believes to be due, in the first place, to a chemical dissociation of the sulphide, and the light is due either to this or to the subsequent re-combination. Thus he dissociates himself from the view that it is the result of merely mechanical bombardment. He has measured the luminosity of the sulphide screen when exposed to emanation from 200 milligrams of radium, and finds that 80 per cent. of the energy of the α particles is transformed into light; about 1/50th to 1/100th of a candle-power is obtainable.

Mr. H. H. Poole described a determination of the rate of evolution of heat by pitchblende. The experiment, which seems to have been made with great care, gave about twice the quantity estimated from the known amount of radium present. Prof. Rutherford was of opinion that possibly a small amount of chemical heating may be present.

Mr. T. Royds, working in Prof. Rutherford's laboratory, described his measurements of the grating spectrum of radium emanation. The error in the wave-lengths of the grating photographs is not more than about 0·1 Ångström unit Prof. Dewar mentioned that the lines published in NATURE agree closely with lines given by himself and Liveing obtained from less volatile constituents of air. The agreement was possibly accidental, but it was well worthy of being tested.

Photographs were next shown, by Dr. W. G. Duffield, of the arc spectra of metals under pressure; these include those of iron and copper under pressures up to 101 atmospheres, and that of silver up to 121 atmospheres.

Mr. H. Stansfield followed with a paper on secondary effects in the echelon spectroscope. These effects arise from repeated reflection from the plates, as in the Fabry and Perot interferometer, and would, if alone, consist of rings; but they are superposed upon the ordinary echelon spectra. By raising one end of the echelon and using screens, the secondary effects can be separated and used alone. The resolving power is much greater than if the secondary effects were absent.

In the cosmical physics department a paper was read by Dr. G. A. Hemsalech on new methods of obtaining the spectra in flames. A special burner is fed with air, which becomes laden with metallic vapour by passing through a bulb containing a spark discharge. Investigation of the iron spectrum showed that the *lowest* temperature flame spectrum consisted of "enhanced" and "polar" lines. Dr. W. G. Duffield welcomed Hemsalech and de Wattville's researches as overthrowing the "temperature" hypothesis of the origin of "polar" lines. Prof. Larmor indicated that the criterion for the production of spectra was not temperature, but the acceleration of the vibrating systems. Sir O. Lodge concurred. Dr. James Barnes stated that he found that the 4481 Mg line appeared as a polar line in the arc spectrum of that metal.

Prof. J. Larmor then showed Dr. G. E. Hale's recent photographs of the spectra of sun-spots taken through polarising apparatus, in which the centres of some lines are shifted relatively to their normal position, the direction of shift being changed by rotating the polariser through 90° (see NATURE and *Astrophysical Journal*, September). The effect is attributed to the magnetic field arising from vortices of charged particles. The bearing upon the phenomenon of the depth from which the light was emitted was discussed. It is a pity that the pressure of papers prevented a discussion on these important photographs from taking place.

A paper by the Rev. A. L. Cortie, S.J., brought forward evidence of the possible existence of steam in the region of sun-spots. In a paper by Prof. Whittaker on sun-spots and solar temperature, the possibility of the existence of compounds in the sun was discussed, and it was shown that pressure may be a more powerful agent in preventing dissociation than temperature is in producing it, and the characteristics of spot spectra may be due to the high pressure.

Mr. E. M. Wedderburn, in a paper on the causes of seiches, brought forward evidence that their most effective cause was a series of atmospheric oscillations nearly coincident in period with them.

M. Teisserenc de Bort read a paper on the difference of temperature of the upper atmosphere in polar and in equatorial regions. At a height of 10 or 11 kilometres there is no difference of temperature in the two regions. Above this height, the arctic temperature keeps constant, while the equatorial continues to decrease. Mr. W. A. Harwood contributed a note on the *ballons-sondes* ascents made at Manchester during 1907–8, which confirm the existence of the isothermal layer.

Mr. J. S. Dines exhibited diagrams showing the results of the *ballons-sondes* ascents made in the international week, July 27 to August 1, 1908.

Captain H. G. Lyons gave the results of observations of upper-air currents in Egypt and the Sudan. Mr. R. G. K. Lempfert, of the Meteorological Office, exhibited a zoetropic apparatus for showing the manner in which cyclonic disturbances move across the British Isles, and the way in which the air circulates. Mr. Paul Durandin read a paper on an asymmetry in cyclones, in which he pointed out that thunderstorms and tornadoes occur generally on the right-hand side of the path of the centre of the large depression with which they are associated.

On Wednesday, September 9, the section sat in single session.

Mr. T. L. Bennett read, on behalf of Mr. J. I. Craig, a paper on the changes of atmospheric density in storms.

The chief results arrived at were that the time-change of density is negative in the front of cyclones and positive in the rear, that the changes are greater in the front quadrant to the right of the path than in the front quadrant to the left, in which, however, the largest rainfall occurs. From an application of the equation of continuity, the vertical velocity of the air in a moving cyclone was deduced.

Dr. Shaw read a paper on the meteorology of the winter quarters of the *Discovery*. He showed a slide of a relief-map of the district in which the *Discovery* spent the years 1902 and 1903, directing attention to the proximity of Mt. Erebus, the cloud from which enabled the observers to determine the upper-air currents. Some surprise was caused by the statement that the annual amount of bright sunshine at this place was as large as that for Scilly. The wind observations corroborated the theory that had been formed regarding the general circulation of the atmosphere in polar regions, *i.e.* an easterly surface wind with a westerly current in the upper air.

Mr. Bernacchi read a paper which was chiefly concerned with the results of the magnetic observations taken during the *Discovery's* sojourn in the Antarctic regions.

The Rev. H. V. Gill, S.J., read a paper on earthquakes and waves in distant localities. An earthquake at one place may cause the premature occurrence of an earthquake at another place. This precipitation is possibly due to the slight change in the distribution of the earth's mass relative to its axis of rotation, caused by the water disturbance accompanying the earthquake.

Dr. Shaw exhibited diagrams illustrating the storm of August 31 to September 1, the B.A. storm of 1908. The diagrams were collected from stations in connection with the Meteorological Office, and showed how the fury of the storm concentrated itself on the line from Holyhead to Kingstown.

Miss C. O. Stevens read a paper on the great snowstorm of April 25.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—The following is the speech delivered by the Public Orator, Dr. Sandys, on Thursday, October 29, in presenting for the complete degree of Master of Arts *honoris causa* Prof. W. J. Pope, Dr. Liveing's successor in the chair of chemistry :—

Viri in Academiam nostram liberalissimi, viri Scientiarum Doctoris nuper honoris causa merito creati, cathedram vacuam relictam occupat hodie vir inter Londinienses natus atque educatus, vir non modo inter Londinienses sed etiam inter Mancunienses scientiam chemicam praeclare professus. Peritis nota sunt opera eius plurima de scientiae illius provincia organica (ut aiunt), deque metallis et crystallis praesertim conscripta. Quae autem ratio intercedat inter corporum naturam pellucidam et primordiorum e quibus corpora illa constent dispositionem, primus omnium (nisi fallor) detexit, et sulphuris, selenii, stanni praesertim in particulis inaequaliter distributis luculenter illustravit. Hodie vero nobis vix necesse est haec omnia subtilius persequi. Satis in hunc diem erit, si professori nostro novo munus suum feliciter auspicato omnia prospera ex animo exoptamus.

Mr. A. R. Hinks has been appointed Royal Geographical Society university lecturer in surveying and cartography, for three years as from Michaelmas, 1908.

Dr. Marett Tims will give a course of ten lectures on the morphology of teeth in the Vertebrata during the present term. The first lecture will be in the laboratory for advanced zoology on Saturday, November 7.

THE Royal University of Ireland has conferred the degree of D.Sc. *honoris causa* on Prof. Alfred Senier, of Queen's College, Galway, in recognition of his services as a teacher of chemistry in Galway and of his discoveries in organic chemistry, notably his work on acridines.

THE Right Hon. Earl Carrington, President of the Board of Agriculture, will open the Edric Hall and new workshops of the Borough Polytechnic Institute on Friday, November 13. This extension of the institute is primarily due to the gift of 5000*l*. by the first chairman of the governing body, Mr. Edric Bayley, which has been supplemented by grants from the London County Council amounting to about 10,000*l*.

AN address on the correlation of the teaching of mathematics and science will be given by Prof. J. Perry, F.R.S., at a conference of the Mathematical Association and the Federated Associations of London Non-Primary Teachers to be held at the Polytechnic, Regent Street, on Saturday, November 28, at 3 p.m. The chair will be taken by Prof. G. H. Bryan, F.R.S., president of the Mathematical Association. Tickets of admission to the conference can be obtained from Mr. P. Abbott, 5 West View, Highgate Hill, N.

THE annual report of the treasurer of Yale University for the financial year ending June 30 shows additions to the funds of the University during the year of 253,000*l*. The principal items are 12,600*l*. from the Yale alumni fund; from the Archibald Henry Blount bequest, 67,400*l*.; from the Lura Currier bequest, 20,000*l*.; by bequest of D. Willis James, 19,000*l*.; from contributions to the University endowment and extension fund, 67,100*l*.; and from balance of the Ross library fund, 22,400*l*. Gifts to income amounted to 15,300*l*., of which 6000*l*. came from the Alumni Fund Association.

THE winter session of the Crown School of Forestry opened on November 2. This little-known institution has its headquarters at Parkend, a small village in the Royal Forest of Dean. In a small shed, rough, unpainted, scarcely weather-proof, sixteen students receive instruction in the theoretical aspect of forestry, and in the surrounding forest they study the practical part of the subject. A nursery plot—two acres in extent—has been cleared, and an enclosure of nearly 200 acres will shortly be set apart for experimental work. The director of the school, Mr. C. O. Hanson, late of the Indian Forest Service, makes up in personal enthusiasm what is lacking in the equipment of the school, and so successful has been the work that the Department of Woods and Forests is spending a considerable sum on the equipment of a new building to accommodate the school.

DR. H. T. BOVEY, F.R.S., Rector of the Imperial College of Science and Technology, in his recent address (NATURE, October 15, p. 616) recommended the formation of associations of alumni by the constituent colleges, and directed attention to the American method of appointing a secretary each year whose office it is to keep in touch with the students who passed out in his year. Dr. E. F. Armstrong writes to point out that the Central Technical College—which is now a constituent institution of the Imperial College—has had an "Old Students' Association" since 1897, which is kept in touch with its members much in the way that Dr. Bovey advocates. It issues an illustrated journal, *The Central*, in which the doings of past students are regularly recorded; it also administers a successful employment agency bureau. The contributions to this periodical have frequently been mentioned in NATURE. Dr. Armstrong also states that a year ago the Old Centralians collected the funds to found a scholarship as a permanent memorial to the long connection of Prof. W. C. Unwin, F.R.S., with their college.

IN a lecture before the Fabian Society on October 28, Prof. M. E. Sadler said that the chief points at which, under present conditions in England, the State should aim, were :—(1) a great reduction in the size of the large classes in many public elementary schools, in order that the teachers might be able to give more individual care to the different pupils; (2) careful medical inspection, at sufficiently frequent intervals, of all school children with the view of securing the due physical development of the rising generation, parental duty in the care of children to be stringently enforced, with liberal aid in cases of